WQB "Wide Aperture Quad" for Main Injector

19 February 2004
IB2 conference room
9:00 AM

Attendees: Leon Bartelson, Bruce Brown, Dave Capista, Weiren Chou, TJ Gardner, Dave Harding, Dave Johnson, Vladimir Kashikhin, Ioanis Kourbanis, Lucy Nobrega, François Ostiguy, John Zweibohmer

Weiren showed the analytical calculation of the change in tune and the beta and dispersion waves generated by a quadrupole strength error. A 1% error in the integrated gradient strength would make a beta wave of about 6% for each location. More work would be needed to know whether the waves from the various proposed locations would cancel or add. The conclusion is that we need the trim coils.

Vladimir showed additional calculations based on the same pole geometry and steel. A circle centered at x=32 mm and radius 19 mm reaches 51 mm, the pole radius. The gradient deviation is about 30 units at 51 mm and less than 5 units within 46 mm.

Dave Johnson showed the overlay of quadrupole and Lambertson apertures from the Main Injector TDR, (http://www-fmi.fnal.gov/fmiinternal/MI_Technical_Design/Chapter%202%20for%20Web.html#The_150_GeV_Lines) along with the beam positions and sizes. After lengthy discussion, the conclusion was that the current design is probably satisfactory but that a modest improvement would be nice. One measure of acceptable field uniformity is whether the magnet is worse than the current Main Ring quadrupoles. Bruce commented that some Main Ring quads had been measured off axis in the 1980's. Dave Harding may be able to resurrect those measurements. Alternatively, the field could be measured. François did the calculations on the Main Injector quadrupoles and still has the magnet description files.

Dave Johnson also showed a calculation showing that, starting from an ideal Main Injector lattice and adding quad errors of 1% at the four high energy extraction points, there is enough cancellation due to favorable phases that the biggest change in beta is about 5%. The tune shift is 0.015. These are deemed acceptable, but correcting the problem is better. Dave could repeat the calculations using the actual quad strengths provided by Bruce.

Although the field quality is probably acceptable, Vladimir will improve it as the design is refined. The field quality should be optimized at low field. The beam is largest at injection; it explores the most aperture during slow extraction.

Lucy has looked at the layout drawings for the magnet locations mentioned as candidates for replacement. The only one that had any serious interference problem was one of the Recycler points, and that turned out to be a case of the wrong magnet being listed. After further discussion, the locations of interest are 402, 522, 608, and 620 for high energy extraction, 101 for injection, and 222 and 321 for the Recycler transfer points. These seven magnets would be backed by two spares.

John Zweibohmer reported that there is still some LTV steel left from the Main Injector project. Further checking is needed to see whether there would be enough for these magnets. It may belong to the LHC, but it is excess. This is the steel Vladimir has used in his calculations so far. John Z

will give Vladimir measurements on some steel that is being considered for the BTeV quadrupoles for his consideration.

TD will provide the beam tubes. The tube will be star shaped, but have a circular flange at the end to match the existing Lambertson flanges. A smooth taper from one shape to the other is highly desirable to minimize the impedance that the beam sees. Wide aperture BPM's that are not inside the quads are already in use at the extraction and injection points, but the Recycler points need to be reviewed.

Leon showed his calculations on using an existing power supply design for the trim coils. Given the current and voltage capability, he would like to see 21 to 24 turns per pole in the trim coils to ensure the ability to boost the field by 2%.

TJ and Dave Harding showed a first pass at a schedule. Missing milestones on design decisions will cause slippage at the end. Long lead time items are typically the steel, the die (and thus laminations), the conductor, and the beam tube. There will be significant design time, but the longest lead tie articles will be done frits. Some fabrication work is likely to happen before the 2002 shutdown, but serious effort will not start until the shutdown is over. With the projected procurement cycles, a slippage in the shutdown will not allow much work to happen earlier and will lead to delays in delivery of the first magnet.

Some key dates:

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| 2/25/04 | Magnetic conceptual design accepted |
| 3/22/04 | Over all conceptual design accepted |
| 7/8/04 | All component designs complete |
| 8/18/04 | All tooling designs complete |
| 9/16/04 | All components in hand |
| 11/11/04 | All tooling in hand |
| 8/19/04 | Magnet fabrication starts |
| 2/7/05 | First magnet complete |
| 3/8/05 | First magnet measured and accepted |
| 6/28/05 | Fifth magnet complete, measured, and accepted. |

Initially we will be limited by designer time, then the procurement cycle and finally by fabrication labor. Getting the first magnet in time for the start serious NuMI running will be a challenge. Getting all of the magnets for the 2005 shutdown is quite reasonable. TD will try to improve the schedule as it is possible, but there is no contingency built in. If the priority is high enough, TD technicians could be held back from tunnel work during the 2004 shut down. This might accelerate the schedule, but would certainly provide a great deal of contingency.

We will need to buy essentially all of the M&S this fiscal year. Dave H's wild guess at a cost for M&S, done in 2002, is in the neighborhood of half a million dollars. TD will work up a better estimate before the next meeting. Ioanis work with AD management to find the money.

Next meeting in two weeks, Thursday, 11 March 2004. 9:00 AM, IB2 conference room. We will try to have:

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| Dave J | Fresh drawings of beam positions, perhaps lattice calculations with actual quad strengths |
| Vladimir | Field calculations with alternative steel |
| François | Field calculations on the IQ series magnets outside the measured region |
| John Z | A statement of the available steel and copper |
| John C | A new conceptual drawing of the cross section, including the trim coils |
| TD | A preliminary cost estimate |